

Scientific significance of the forest vegetation ecotone between Daxing'an Mountains and Xiaoxing'an Mountains to study of global climate change

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Abstract: Daxing'an Mountains and Xiaoxing'an Mountains are the two regions of the highest latitudes in China. The temperature increase is most obvious there in the last hundred years, compared with other regions of China. The forest vegetation ecotone between Daxing'an Mountains and Xiaoxing'an Mountains is located between the latitude 48° and 53° N and longitude 123° and 128° E. This ecotone is of great importance in study of global climate change due to its transitional feature of broad-leaf-coniferous mixed forest and boreal forest. The location, geomorphology, climate, soil and vegetation types of the ecotone are introduced in this paper.

Key words: Ecotone, Global climate change, Daxing'an Mountains, Xiaoxing'an Mountains, Temperature rise

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Introduction

The global climate change is a widespread, long-term environmental change with profound consequences. Since 1980s, scientific evidence about global climate change and its consequences have led to growing concerns among scientists, policymakers and the public. The climate change will result in temperature rise on global, regional and local scales, and change of precipitation pattern, and prospect for more severe extreme high temperature events, floods and droughts in some places.

As the research of global climate change progresses, scientists focus research on reaction and feedback of terrestrial ecosystem to global climate change. Forest is the major component of the terrestrial ecosystem, and the climate change will affect forest ecosystem greatly on structure, function and distribution (Liu 1998; Li 1999). Research showed that the northern high latitude regions will warm relatively more than areas nearer to the equator, which means the terrestrial ecosystem in the high latitude regions will be under more influence of climate change, therefore the northern high latitude region has been playing more and more important role in global climate change research (Liu 1997).

Location and significance of the ecotone

The forest vegetation ecotone between Daxing'an

Mountains and Xiaoxing'an Mountains is a narrow zone located between the latitude 48° and 53° N and the longitude 123° and 128° E, and approximately 600 km in length, including part areas of Heilongjiang Province and Inner Mongolia. The ecotone, which spans the transition zone of coniferous-broadleaf mixed forest and boreal forest, has experienced the most obvious global warming in China, and is characterized by a very high sensitivity to climate change due to its transitional features (Zhou 2000a), thus it will react to the global change much earlier than other ecosystem nearby. This ecotone region is one of the largest national forest regions. Climate change will have a significant influence on the ecosystems, and can have profound impacts on the economy and the quality of life for millions of people living in the region. It is necessary to study the impact of climate change in this region in order to obtain a better understanding of reaction and feedback of ecosystem.

Topography of the ecotone

The topography of this ecotone region is very diversified, inclined with the elevation increasing from the SE corner to the NW corner. The southeast corner of the ecotone is at the northern slope of Xiaoxing'an Mountains, with the altitudes ranging from 250 m to 600 m, and there are also some plains near the Heilongjiang River valley. The north-western corner of the ecotone on the northern slope of Daxing'an Mountains is characterized by steep slopes, thin soil layer, low temperature, and the slowest tree growth. Its highest elevation is 1529 m.

Climate of the ecotone

The ecotone is the northernmost region in China. Its

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southeast corner belongs to the northern border of temperate climate zone, with long and cold winter and short, mild, rainy summer. Its northwest corner is at the cold temperate climate zone, the coldest region in China.

Climate gradient

In the southeast-northwest direction along the ecotone, the climate varies greatly (Table 1).

Table1. Climate gradients in the ecotone between Daxing'an Mountains and Xiaoxing'an Mountains*

Item	Value
Mean annual temperature (°C)	1.1~4.6
Mean temperature of January (°C)	-24.5~-30.2
Mean temperature of July (°C)	19.1~18.4
Warmth index (°C)	69.2~32.1
Coldness index (°C)	-80.5~-159.8
Annual precipitation (mm)	590~400
Precipitation of January (mm)	3.5~3.6
Precipitation of July (mm)	121.4~104.2
Aridity index	5.9~8.7

History of climate change

Research has demonstrated that the rate of warming in 1980s is the most rapid in recent 40 years. The northeast China has the most magnitude of warming in China. Especially, the ecotone between Daxing'an Mountains and Xiaoxing'an Mountains, which is located in the northernmost region of northeast China, has the same warming trend as in the north Hemisphere in last hundred years.

By analyzing the climate data from meteorological stations located in the ecotone, we found that there exists remarkable difference in climate change for different parts of this region (see Figs 1~4). Sunwu is situated at the southeast part of the ecotone, Tahe is at the northwest, and Huma is near the center of the region. The mean annual, mean annual maximum, and mean annual minimum temperatures tend to rise in Sunwu and Huma areas, but Tahe had a decrease in mean annual temperature and mean annual minimum temperature. There is a great uncertainty in determining the trend of annual precipitation due to its large variations.

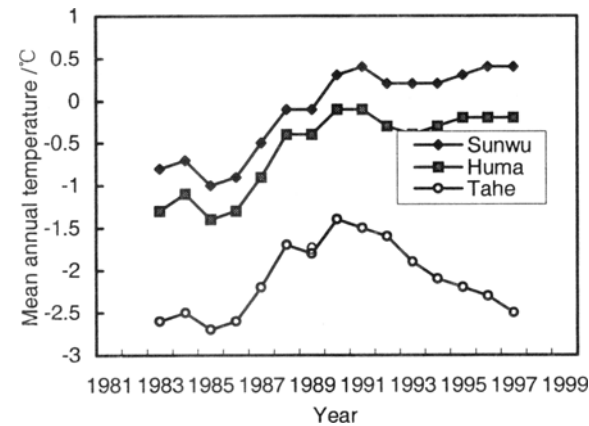


Fig. 1. The changes of mean annual temperature with years from 1980s to 1990s in the ecotone

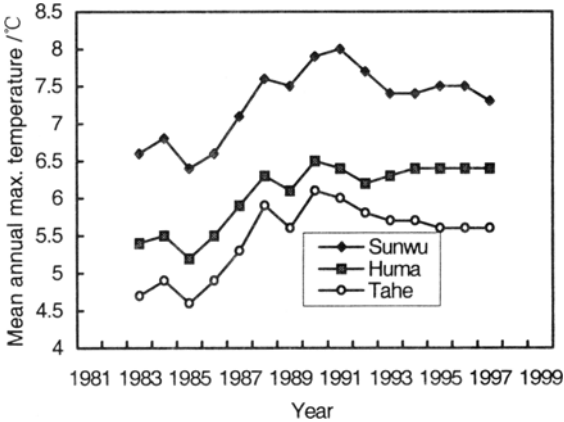


Fig. 2. The Changes of mean annual max. temperature with years from 1980s to 1990s in the ecotone

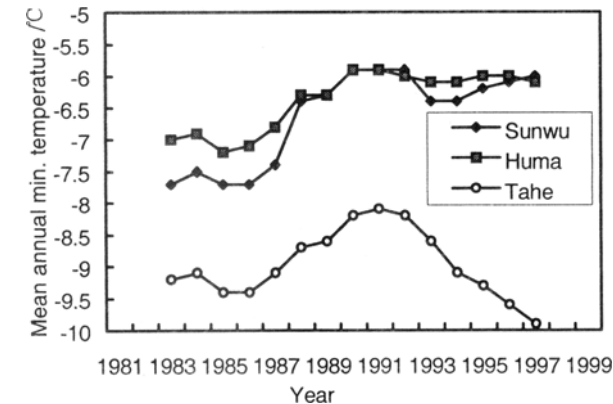


Fig. 3 The changes of mean annual min. temperature with years from 1980s to 1990s in the ecotone

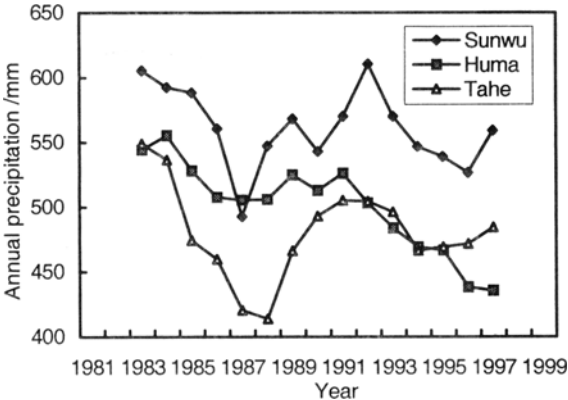


Fig. 4 The Changes of mean annual precipitation with years from 1980s to 1990s in the ecotone

Analysis of the monthly data from all the meteorological stations in the ecotone showed that in recent 20 years, mean monthly temperature and mean monthly maximum temperature increase obviously in February; mean monthly minimum temperature increase obviously in February, May, June, July and October. Warming in this magnitude will affect many aspects of the ecosystem and society as it changes temperature and precipitation patterns, vitality and productivity of the forest, induces forest fire and breakouts of diseases and pests.

The frost-free period in 1990s were obviously prolonged comparing to 1980s in Heilongjiang province, especially in high latitudes (50° N), which contributed to the continuously increased crop yields in the Heilongjiang Province since 1983.

Soil of the ecotone

In the southeast part of the ecotone region, the dark brown soil is the major soil type, usually distributed in mountainous areas. The low land on riverbank is covered by bog soil, and there exist some deep and fertile meadow soil and black soil. At the lower part of northern slope of Xiaoxing'an Mountains, there are some permafrost mosaics, soil layer is thin, with a depth of 15-30 cm. In the northwest part of this region, the major soil type is brown coniferous forest soil, which contains high amount of sand, and low amount of humus, and there are large areas of permafrost, which is distributed in valley regions.

It has been observed that formerly frozen soils in the southern slope of Xiaoxing'an Mountains have begun to melt or have disappeared in some places, which has caused damage of some forest ecosystems such as spruce forest. The warming will also lead to more rapid decay of organic matter and the release of trapped carbon.

The permafrost wetland in Daxing'an Mountains is an important water resource, playing a key role in maintaining the ecological balance of Heilongjiang and Nenjiang drainage. The permafrost environment is the base for existence of natural larch forest. Melt of permafrost induced by climate change could lead to disappearance of larch forest.

Vegetation in the ecotone

The ecotone region between Daxing'an Mountains and Xiaoxing'an Mountains belongs to transitional zone between Korean pine (*Pinus koraiensis*)-deciduous mixed forest in Xiaoxing'an Mountains and larch (*Larix gmelini*) forest in Daxing'an Mountains.

At southeast corner of this ecotone, vegetation is considered to be the northernmost coniferous-deciduous mixed forest characterized by the dominance of Korean pine. However some spruce-dominated coniferous mixed forest also appear, some typical broadleaf tree species of the Korean pine mixed forest disappeared gradually. Sec-

ondary oak forests and mosaics of larch forest are common. Some species such as *Rhododendron dauricum*, *Ledum palustre*, *Vaccinium uliginosum*, *Pyrola incarnata*, belong to East Siberian flora of Daxing'an Mountains.

The Yilehuri mountain range lies in the center of the ecotone and has influences on the vegetation distributed in both sides of it. In the southern slope of Yilehuri Mountain, the vegetation is characterized by combination of cold-temperate and temperate flora components, and the zonal vegetation is Larch (*Larix gmelini*) forest mixed with deciduous species. In the northern slope of Yilehuri, the zonal vegetation is forest of *Larix gmelini* and *Rhododendron dauricum*. The species components belong to typical East Siberian flora.

At the northernmost part of Daxing'an Mountains, the climate is extremely cold but humidity, and vegetation appearance is simple, short and sparse. The dominant species is *Larix gmelini*, *Pinus sylvestris* var. *Mongolica* and *Betula platyphylla*.

Researches (Shao 1995; Guo, *et al.* 1998; Yan *et al.* 2000) have reported that Korean pine-broadleaf mixed forest would grow only on higher mountains, and larch forest would lose more than half of the total distribution, and would move farther north due to warmer climate in the future. The southern part of the larch forest would be replaced by birch, aspen, or oak dominated broadleaf forests. Such a large change in the forest structure and composition of the region would have potential impacts on forest management activities in northeast China.

Distribution of larch forests, the zonal vegetation of Daxing'an Mountains, is tightly linked with permafrost. The natural geography and ecosystem in Daxing'an Mountains is characterized by the permafrost forest ecological environment. Under control of the climate, permafrost and larch forests store the fresh water together, forming a cold, wet condition. This region serves as a safeguard of Songnen and Liaohe plains, sustains the ecological balance in northeast and east Inner Mongolia. However, climate extreme events such as floods and fires occur frequently in Daxing'an Mountains in recent two decades. Deforestation also worsened the stresses. The ecological functions of the forest ecosystem have been greatly reduced.

Land use in the ecotone

The land use in this ecotone region is simple, characterized by forestry. The total area of the ecotone region is approximately 12,440.3 thousand hm^2 , of which the woodland is 9,810.6 thousand hm^2 , making up 79% of the total area, with a forest coverage of 60.9%, and the farmland is 2,620.7 thousand hm^2 , making up 21% of the total area, and decreases from the southeast corner to the northwest of the ecotone. In Daxing'an Mountains, agriculture is limited by low temperature.

Because of the relatively short history of exploration in the ecotone area, there are still some places remaining

intact, including various forest ecosystems. Thus the human factor can be excluded in study on impact of climate change to ecosystem.

Discussion

Although the influences of climate change are pronounced, ecosystem responses are not necessarily immediate, which makes it difficult to reveal the impact of climate change and feedback of ecosystem. In this ecotone, the forest ecosystems are already vulnerable to the environmental pressures. Global warming is likely to amplify the effects of other pressures. Thus, it is relatively easier to observe the reaction of forest ecosystems, such as regeneration and invasion of broadleaf species induced by climate change, make it possible to predict the changes of forest in composition, function, distribution and structure in this region.

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